In paragraph 7 of the Notice, referring to the ACATS proposal as the "ATSC DTV Standard"[27], the commission states as follows:

"We believe that the ATSC DTV Standard embodies the world's best digital television technology and promises to permit striking improvements to today's television pictures and sound; to permit the provision of additional services and programs; to permit integration of future substantial improvements while maintaining compatibility with initial receivers; and to permit interoperability with computers and other digital equipment associated with the national information initiative. It was developed and tested with the unparalleled cooperation of industry experts and consists of several discrete layers..."

In response to the commission's request for comments on such statements within the Notice, DemoGraFX wishes to challenge nearly every premise being put forth in this paragraph. DemoGraFX does not accept the assertion that the ATSC DTV "standard" proposal represents the world's best digital television technology, since it is demonstrably inferior to the DemoGraFX system, and may be inferior to other systems as well. There is little, if any, provision for additional services. Such additional services will be limited with the ATSC DTV proposal.

Integration of future improvement is mostly precluded, and such improvements, if possible, would almost certainly not maintain compatibility with initial receivers. Interoperability with computers and other digital equipment is not only not being provided by the ATSC DTV proposal, but substantial barriers are placed in the path of such interoperability. A national information initiative is therefore all but precluded from taking advantage of Advanced Television, under the ATSC DTV proposal.

The participants who developed ATSC DTV proposal were a relatively closed group who did not cooperate with those outside of their group. The ATSC DTV proposal therefore represents the interests of a small group of companies, and not a broad industry consensus based upon "unparalleled cooperation".

The "layers" being described are the format, coding, packetization, and modulation. These layers are required by any viable proposal, and do not represent anything of special value. The formats themselves, however, are not layered, but are rather four disparate resolutions in two aspect ratios at eight disparate frame rates. This does not represent a layered system of formats or frame rates, but rather represents a "menu" of widely divergent formats, resulting in substantial cost and confusion at every part of the system.

3. Detailed Comments, The ATSC DTV Proposed Standard (Section III of the Notice)

In paragraph 8 of the Notice, the format layer is described as the "format selection function", the coding is separated into video and audio coding, packetization is called "transport", modulation is called "RF/transmission", and a separate layer is claimed for the receiver. This confusing

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[27] The ATSC is a private industry group representing member companies. It therefore is no different than any other industry coalition or trade association. It is not an accredited standards body. Reference to the ATSC DTV proposal as a "standard" must be viewed in light of it being documented by the participants for their own use. The ATV DTV "standard" does not represent a "standard" in the normal use of the term, since it is not in use, even narrowly (thus not being a de-facto standard), and it is not a standard based upon due process of an accredited standards body representing all interests, since it was based only upon the input of member companies (thus not being a de-jure standard). Note that no computer companies are members of the ATSC, with the exception of Texas Instruments, which only joined recently

presentation of the inherent system layers hides the crucial issue that the format is not itself layered, but is rather a switch between disparate formats which is termed the "video format selection function". This is a crucial distinction and represents a serious limitation of the system's flexibility as well as resulting in substantial cost at every receiver.

The concept that a format is chosen from a large and varied menu of formats is presented in this paragraph as representing flexibility and "numerous acceptable options". In reality, the options are limited to choices on the menu which are unacceptable for many applications. Further, the very existence of so many choices results in constraints on what the receiver must decode, rather than representing flexibility. The numerous formats represent flexibility only in the sense that it allows the sender to choose from many different television formats. For creators of shows and for receivers of the signals, the sender's flexibility represents a greatly increased burden, in that numerous formats must be created and decoded. Further, when the decoded format does not match the format of a given display, conversion is then required in the receiver. Since no display is likely to operate at every format which can be chosen by any sender from the ATSC DTV menu, it is likely that every receiver will require a conversion unit. This conversion unit will be expensive, and it will degrade quality.

For computer-compatible displays, which do not use interlace, and which operate at display rates exceeding 70 Hz, the cost of this conversion will the greatest of any type of display, and the quality loss will be the worst. Thus, computer-compatible displays, which are the key ingredient of a national information initiative, will be greatly disadvantaged if the commission adopts the ATSC DTV standard.

For this reason alone, the commission should reconsider its intention to adopt the ACATS proposed ATSC DTV system. The selection of an Advanced Television standard for the United States should have the enablement of a national information infrastructure as the highest priority. Claims being made that the ACATS proposed ATSC DTV system enables the national infrastructure are without merit. On the contrary, the ACATS proposed ATSC DTV system erects formidable barries in cost, illegibility, and lost opportunity toward erecting Advanced Television as the key ingredient of a national information infrastructure. The ACATS proposal, if accepted, is likely to create a several-decade-long barrier to the unfolding of a national information infrastructure. It would further greatly disadvantage the computer industry, which would be the key industry to create the infrastructure and technology. The result of adopting the ACATS proposal will be to enshrine the digital advanced television system as being only useful for entertainment, news, and sports, in the manner that existing televisions already provide these services. Existing NTSC television has not proven more broadly useful, and rarely used in interactive services to the home. The ACATS proposed system would not be much more useful than existing NTSC, thwarting ATV's inherent potential.

The NTSC format technology in existing televisions uses 59.94 Hz and interlace. NTSC television displays were abandoned by the computer industry for information display purposes over a decade ago. Early personal computers which used the television set for display were limited to twenty lines of text, where each line contained 40 characters or less. This is an insufficient amount of information for computer data presentation, and such displays were quickly abandoned in favor of screens which do not use interlace and which provide clear flicker-free images of substantial amounts of text and graphics.

3.1. Detailed Comments on Format Selection (Paragraph 9 of the Notice)

In paragraph 9 of the Notice, the proposed menu of formats is listed. The ACATS proposed ATSC DTV system introduces a new high resolution interlaced format (1920 x 1080 at 60i or 59.94i). Although the horizontal resolution of this format is very high, the vertical resolution is limited by the interlace to about 540 lines (half of 1080) when viewing text. This is almost the

same vertical resolution as an old low-cost VGA computer monitor, which was the computer industry standard about five years ago. It is also very nearly the same vertical resolution as the two 480-line formats without interlace in the menu (so-called "480p" formats). This 1080-line interlaced format has less vertical resolution for text than the 720 line format (1280 x 720) in the menu.

Thus, the interlace cripples the resolving power of the interlaced HDTV format to the point where all other formats match or exceed its performance on text. It is therefore essential that the reason for this format's inclusion be discovered and scrutinized.

Although it is not mentioned anywhere in the Notice, this 1920 x 1080 interlaced format is nearly identical to the Japanese failed HDTV format[28], which is 1920 x 1035 interlaced. Both formats operate at 60 Hz. It has further been rumored that the majority of the public showings which have presented the Grand Alliance HDTV system (the HDTV portion of the ACATS proposed ATSC DTV system) have utilized this Japanese standard. If this is true, then the Japanese HDTV standard was, in fact, a major component of the Grand Alliance HDTV system, while it was being represented as the new All-American digital television standard.

The differences are fundamentally trivial between the Japanese HDTV standard, at 1920 x 1035 lines at 60 Hz, and the U.S. interlaced HDTV proposed ACATS ATSC DTV format of 1920 x 1080 lines at 60 or 59.94 Hz interlaced. For the purpose of evaluating the suitability of these formats for the United States, these formats are practically identical. Both are about as far from computer compatibility as can be imagined.

The Advanced Television Test Center (ATTC), which tested the Grand Alliance ATV system, utilized cameras, tape machines, and other equipment which operated in the Japanese interlaced HDTV format. The majority of this expensive HDTV television equipment was made by Japanese companies. The high cost and value of this equipment brings into question whether such equipment might have been discounted when it was provided to the testing center. If so, the objectivity of the testing process run by ACATS may be called into question.

Both Japanese and European consumer electronics companies have been publicly adamant that this 1920 x 1080 interlaced format remain in the U.S. advanced television standard proposal by ACATS.

The only U.S.-based Grand Alliance members to endorse the inclusion of an HDTV interlaced format were General Instrument, and Sarnoff Television Research Labs. Sarnoff Labs is closely tied to European-based Thomson Consumer Electronics, who funds the majority of Sarnoff Lab's research work. General Instrument hedged its bets by also backing MIT's non-interlaced system. AT&T and Zenith (Zenith was then a U.S. company) were proposing a non-interlaced system. When the Grand Alliance formed, all the companies must have agreed to endorse the inclusion of the 1920 x 1080 interlaced format. Since that time, AT&T has switched its public position from objection to vehement endorsement of the inclusion of the 1920 x 1080 interlaced format.

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[28] Although the Japanese HDTV system failed to gain significant acceptance in the market within Japan, it did demonstrate the potential image quality of HDTV. The world owes a debt of gratitude to Japanese industry for their pioneering work in developing HDTV in the 1970's to show the world its potential. However, the Japanese HDTV system is rooted in old analog television technology principles, such as 60 Hz and interlace, which are not suitable building blocks for a computer-compatible U.S. system.

In this confusing array of companies and positions on the HDTV interlaced format, it should be noted that few, if any, U.S. companies who might manufacture HDTV equipment for the U.S. have endorsed the inclusion of the interlaced HDTV format. Nearly all of the U.S. companies who have endorsed its inclusion are companies who would be buying such equipment (such as some broadcasters), presumably from Overseas manufacturers.

The U.S.-owned manufacturing companies who have taken an interest in the standard, such as computer companies, have nearly all come out in favor of removing the interlaced HDTV format, and most wish to remove interlace from the SDTV formats as well.

Two key members of the movie production community, the American Society of Cinematographers (ASC), and the Directors Guild of America (DGA), have also strongly opposed interlaced formats, especially interlaced HDTV. Steven Spielberg himself has written to the commission on this point.

Both the computer industry and the motion picture production industry add strength to our national economy. The motion picture industry is one of the nation's largest contributors to a trade surplus. The consumer electronics industry, on the other hand, is a major force in the national trade deficit.

Thus the landscape of those who endorse inclusion of the interlaced HDTV format (1920 x 1080 interlaced) might usefully be separtated into the interests of U.S. companies and the interests of foreign-owned consumer electronics companies, and those to whom these same consumer electronics companies wish to sell television production equipment[29]. This is not to say that these same foreign-owned companies do not also often produce computer equipment, computer-displays, and other computer-compatible equipment free of interlace. However, in advanced television, many of these companies do not support the principles which enable their computer-compatible display and equipment divisions. Such companies have been actively endorsing the inclusion of the 1080-line interlaced HDTV standard into the menu of the ACATS proposal.

The Honorable Chairman Reed Hundt, at the en banc hearing on Advanced Television, proposed a method of dealing with this controversy by recommending for consideration the idea that the commission might be able to "let the market decide" about whether interlaced formats are utilized or not. The commission could do this by adopting ACATS, and letting broadcasters decide whether to transmit interlaced formats or not ("format selection function"), and letting viewers decide which televisions to buy and which programs to watch. Unfortunately, the only production cameras and tape systems available for broadcasters are interlaced. This is not because non-interlaced cameras and tape systems couldn't be available[30]. There has been no

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[29] One noteable exception is the Matsushita/Panasonic effort to build and demonstrate a 480-line non-interlaced (also called progressive-scan) television system in conjunction with Nippon Television (NTV). That praiseworth effort has shown the potential quality from non-interlaced television, even at the low 480-line resolution. This quality improvement comes solely from the removal of interlace.

[30] The Matsushita/Panasonic NTV system included cameras, coders, and tape systems, although in prototype form. The Polaroid 720-line non-interlaced camera is also now being demonstrated in prototype form. It is worthy of note that both systems were developed in less than two years from project start to working prototype systems with high quality specifications. These prototypes can most likely be upgraded to production equipment in a very short time, however both suffer from the 60 Hz frame rate, and the NTV 480-line system has non-square pixel spacing. Thus, further modifications are necessary before computer-compatible equipment would be available to broadcasters.

incentive for the makers of interlaced production equipment to also design non-interlaced equipment as well. These manufacturers have a vested interest in the commission accepting the interlaced HDTV format so that they need not invest in the non-interlaced equipment development.

Thus, by accepting the ACATS proposal to include interlaced 480-line and 1080-line formats, the commission would likely see a result that only interlaced HDTV and SDTV formats were introduced for U.S. advanced television's initial years. This would, in turn, bias consumer receiver displays to be interlaced, rather than bear the extra cost and quality loss of a de-interlacing sub-system in each receiver.

These events, in turn, will engender the spread of the computer-incompatible interlaced formats, both being transmitted, and being displayed. The result will be the prevention or multi-decade delay of advanced television as a key enabler for a national information infrastructure.

The commission may wish to investigate the likelihood of this scenario by querying those broadcasters who wish to become initial licensees for HDTV. There have been announcements that stations in Washington DC[31] and North Carolina wish to apply for licenses to begin HDTV broadcasting. Other stations are rumored to also be planning to apply for HDTV broadcasting licenses in the near future. The commission could ask each such aspiring HDTV broadcaster to reveal their plan for which HDTV studio equipment they plan to purchase, and which ACATS proposed formats they intend to transmit. The commission would then be able to verify our assertion that Japanese HDTV equipment will become a substantial portion of the initial HDTV broadcasting equipment in the United States if the ACATS proposed ATSC DTV system is deployed as stated in the Notice[32]. Further, the commission will be able to verify that these systems will initially be broadcasting in the HDTV format which is identical to the HDTV Hi-Vision format used in Japan by NHK for their analog satellite-based MUSE broadcasting system.

If the commission accepts the ACATS proposed ATSC DTV system, the likely scenario is that the United States will have only interlaced television broadcast and display, and our citizens will thereby be deprived of the full potential for a national information infrastructure. Thus, the commission must prevent the inclusion of interlaced formats in the menu of options.

3.2. Detailed Comments on The Format Table (Table I and Paragraph 10 of the Notice)

Table I in the Notice contains four different resolutions in two aspect ratios at four different frame rates. These formats are described in paragraph 10 of the Notice. Adding up the number of entries in the table yields 18 different format options under the ACATS proposed ATSC DTV system.

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[31] According to the separate comments of the Honorable Commissioner James H. Quello, WETA in Washington DC, a PBS station, has filed an application for authority to operate an experimental ATV station. WETA is located adjacent to the Advanced Television Test Center (ATTC), and may be intending to use the interlaced Japanese-format HDTV equipment which is housed there.

[32] ABC has announced its intention to use progressive scan (non-interlaced) formats to begin broadcasting in 1998, if approved by the commission. While this is very encouraging, the absence of other broadcasters making similar announcements leads to the inference that the majority of broadcasters may still be planning to deploy interlaced ATV equipment for HDTV broadcast.

Although these options may have been attractive to broadcasters by providing them with numerous choices, the large number of options creates severe problems for those involved in the creation of new shows and for receivers. There are serious difficulties in conversion and processing of such a wide array of formats.

The concept that the ACATS proposal is allowing choices is inconsistent with the high burden being placed on show producers and receiver manufacturers when attempting to interoperate with the numerous disparate formats being proposed in Table I. Thus, the formats of Table I do not represent choice for any industry other than broadcasters, but rather these formats represent a costly and image-degrading burden. Although it may sound politically attractive to allow many choices and to let the market decide which choices might be most attractive, the burden that all receivers receive all formats is not a choice scenario for receiver manufacturers, but is a scenario of extensive constraint.

However, if a receiver could extract from a layered ATV format system the most optimal format layer for that given receiver, then cost could be minimized, and quality would be maximized for every such receiver. Such a system would represent true choice for the consumer, contrary to the ACATS proposed formats in Table I, which represent a choice only for the broadcaster. True market forces could then operate to help receiver manufacturers and consumers find the optimal balance of cost and quality in a truly open market where there is true choice. The ACATS proposal does not yield such market competition, and does not lead to choice, contrary to assertions in this section of the Notice.

The options in Table I can be reduced to a single layered system, as is being proposed by DemoGraFX. This would further simplify the ATV image format system to be a common unified layered format which is sent by all.

Such a layered approach would allow the desired flexibility for the receiver market. The base layer would provide high quality similar to the 480-line non-interlaced format[33] with a very low cost decoder in the receiver, and an even lower cost converter box for existing televisions. Enhancement layers provide further improved HDTV performance superior to the ACATS Grand Alliance HDTV formats which are being proposed in the top two rows of Table I.

The DemoGraFX ATV system is described in greater detail in *Appendices I, J, and K.*

We will now provide further detail into our specific objections concerning the resolutions and frame rates being proposed in Table I. In particular, we will show how the resolutions and frame rates within Table I are based upon unsound principles. These numbers are derived from fundamental parameters which have their basis in decades-old technical and marketing issues which are now obsolete and irrelevant.

We will first begin with the vertical and horziontal resolutions in the first two columns of Table I.

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[33] Many people who view the Matsushita/Panasonic NTV demonstration of their 480-line non-interlaced system think they are seeing HDTV. There is a very large quality improvement from removing interlace from the television format, even at the low 480-line resolution of NTSC. The DemoGraFX system's base layer differs from this 480-line non-interlaced system in a number of ways, but the appearance will be similar or better. The greatest improvement is DemoGraFX treatment of widescreen (2.37:1 aspect ratio) movies. DemoGraFX provides a 75% clearer image than the 480-line SDTV formats in the ACATS proposal for widescreen movies.

As mentioned above, the 1920 x 1080 interlaced format (shown as 60I in the table), should be eliminated by the commission, even if nothing else about the proposed ACATS ATSC DTV system is changed. The elimination of this interlaced high definition format is the most crucial issue before the commission. ACATS is recommending that it be allowed. DemoGraFX urges the commission to disallow it. ACATS admits that this format should be temporary. ACATS proponents readily admit that it would be desirable to "migrate to progressive scan". ACATS agreed to prepare a migration strategy which moves away from this format and to all-progressive formats as a condition of endorsement by groups mentioned as endorsees of ACATS in this Notice. However, ACATS has not been able to show any viable mechanism to replace or eliminate this format in the future, once it is deployed[34]. Thus, the only viable way to prevent this format from becoming the defacto American HDTV standard for decades is to prevent its use from the outset.

It can be easily seen that once consumers purchase interlaced sets in this format, that such sets cannot be recalled. Similarly, once broadcasters begin their investment in interlaced cameras and tape systems in this format, such investments cannot be easily discarded, and many such systems cannot be upgraded, but rather must be replaced. Thus, there is no practical and viable strategy for recalling interlace once it is deployed. Acceptance of the ACATS proposal, as is contemplated in this Notice, is equivalent to a permanent deployment of digital interlaced HDTV formats for the United States. There is only one strategy to avoid this, which is not to deploy any interlaced formats in the first place. This is the most fundamental and critical issue concerning the ACATS proposal.

In addition to the critical issue of not deploying new digital interlaced television formats in the United States, even the non-interlaced formats in Table I of the Notice are problematic.

Only one of the formats, 640 x 480 at 24P, is desirable. The other 17 formats are highly undesirable.

In the third row of Table I, a format of 704 x 480 is proposed at various frame rates. The 704 x 480 formats all have non-square pixel spacing. In the 16:9 proposed aspect ratio, the pixel spacing is squeezed non-square by a ratio of 37/40. In the 4:3 aspect ratio, the pixel spacing is stretched non-square by a ratio of 10/11. These amounts, which are near 10%, are sufficiently large that circles will appear to be oval if these spacings are not corrected to square. Since all computer-compatible devices use squarely-spaced pixels, all such devices will be required to apply these odd ratio conversions. This places a further burden on computer compatible receivers. The cost of conversion to squarely-spaced pixels at the broadcast source is minimal in the context of a broadcast plant. The cost at every computer-compatible receiver is significant. This is especially an issue for software decoded video, which is becoming feasible in the next couple of years.

The origin of the 704 number is worthy of note, since it is so problematic. The 704 horizontal value is based upon 720 horizontal, with an 8 pixel border pad on the left and right for signal processing defects at the edge of the image. The 720 horizontal value, in turn, was based upon the desire of digital broadcast tape recorder manufacturers to sell a common tape machine in both NTSC countries, such as the United States and Japan, and 50-Hz PAL countries, such as in England and other parts of Europe. The 720 horizontal number comes from a factor of six times the least common multiple of the horizontal scanning rates of NTSC and PAL. This least common multiple is 2.250 MHz. The 720 horizontal format, has a 9/8 squeezed pixel spacing for NTSC, and a 15/16 stretched pixel spacing for PAL. This digital video standard, with non-square pixel spacing, was selected in the early 1980's in order to provide digital video tape manufacturers with a common clock rate for PAL and NTSC. In practice, a PAL tape could not

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[34] These endorsements are therefore called into question (see Paragraph 62 of the Notice).

be read in NTSC mode, and an NTSC tape could not be read in PAL mode. However, such tape machines could read or write either a PAL tape or an NTSC tape. In practice over the years, since this CCIR 601 standard was created, this dual-mode capability has been little used. Newer digital tape formats have not chosen to utilize this feature, since there has been little customer demand. Yet the desire by some foreign-owned broadcast equipment manufacturers, over a decade ago, to have single tape system for both PAL and NTSC, has burdened the digital video world with the headaches associated with non-square pixel spacing for the last decade since this standard began to be used. The very first customers of these tape systems complained about this problem, but by that time the standard was in place and it was too late[35]. The reasons that lead to the horizontal numbers of 720 and 704 are now obsolete and irrelevant, yet we see these numbers appearing as the ACATS proposed ATSC DTV system being recommended for new national digital television deployment.

The burden placed on a few hundred production facilities by non-square pixel spacing may be unpleasant but tolerable. Placing this burden on every future home's digital television receiver, with corresponding limitation and expense, is a much larger issue.

The commission has the opportunity to prevent further entrenchment of the non-square pixel spacing associated with 704 and 720 horizontal formats by rejecting these formats within the ACATS proposed ATSC DTV system. The third row of Table I in the notice should therefore be eliminated based upon lack of square pixel spacing.

The 1920 horizontal value in the 1920 x 1080 format also derives from the 720 horizontal value of CCIR-601. The 720 value was doubled, yielding 1440. Then the aspect ratio difference between 4:3 for the 720 value (CCIR-601) and 16:9 for the 1920 value was applied, being an additional factor of 4:3. The result is 1920. Since the starting point of this calculation is the 720 value, which has a non-square pixel spacing, the entire calculation is invalid.

This 1920 horizontal value has been used since 1989 with the Japanese interlaced HDTV standard, which has non-square pixel spacing with 1035 lines. Once the 1920 number was determined, and fixed by the Japanese interlaced HDTV standard, the ATSC attempted to "retrofit" a square pixel-spaced vertical resolution of 1080 onto the 1920 number. This peculiar adjustment was the subject of substantial controversy within the ATSC, as was illustrated by DemoGraFX letter of February 1990, shown in *Appendix A*.

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[35] Gary Demos' former company Whitney/Demos Productions (WDP), was the first company to acquire CCIR-601 tape machines and digital disk recorders. WDP was the first company to deliver on-air digital video from tape, for CBS' coverage of the 1988 elections. WDP complained to the foreign tape machine manufacturer that the non-square pixel spacing was doubling the rendering time (once for CCIR-601 at 720, non squarely-spaced, and once for texture maps with squarely-spaced pixels). However, the digital tape manufacturers appeared insensitive to these comments from their first customer. Prior to this, in Gary Demos' Digital Productions, digital video disks were utilized to provide the first on air digital video, which came directly from pre-loaded digital video disks. This was used for CBS' coverage of the 1986 elections. Several members of DemoGraFX, including Gary Demos, were involved in this work, which pre-dated the formation of DemoGraFX in mid 1988. DemoGraFX has thus been aware from the inception of digital video systems that they have been fraught with shortcomings. It is also worthy of note that Digital Productions created television network identification images ("logos") for ABC, Turner, Fox, CBS, and others during the decade of the 1980's. These images were all created on film, due to problems with the NTSC interlaced video format. Gary Demos, and other personnel within DemoGraFX have created many of the images seen daily on television during the last two decades (since 1976).

A fresh approach to the 1920 x 1080 format would almost certainly move these values to the nearby powers of two, resulting in 2048 x 1024. Both formats fill 2 million pixels, but the 2048 x 1024 format has the advantage of a more aesthetic 2:1 aspect ratio, as well as being more suitable for digital display systems. However, with the 1920 number entrenched in the Japanese interlaced HDTV standard, and with the 16:9 aspect ratio entrenched into the ACATS process, the politically-motivated result was the first line of Table I of the notice. This entire line should be disallowed by the commission. No formats having 1920 as the horizontal value, nor 1080 as the vertical value, are appropriate for wide deployment within the United States. These numbers have their roots in derivations from non-square-pixel spacing and the problematic 16:9 aspect ratio.

The 16:9 aspect ratio is problematic not only because it is aesthetically unpleasing to the creative community. The peculiar value of 9 in the denominator of 16:9 leads to difficulty in may parts of the digital implementations. For example, in the SDTV formats proposed, a 480 line vertical resolution leads to a horizontal value of 853.33333... when using 16:9 and a square pixel spacing. It is not possible to construct systems with 1/3 of a pixel, nor is the value of 853 near to any 16-divisible MPEG-2 macroblock boundary. This motivates such suggestions as the 704 x 480 format on line 3, which has non-square pixel spacing. Thus, numerous immediate and tangible technical difficulties arise due to the choice of 16:9 in the ACATS proposal.

Note that this problem is sufficiently serious that the ACATS formats within Table I do not form a matched system. The SDTV formats have both 4:3 and 16:9 aspect ratios. The 16:9 aspect ratio formats use 704 x 480, which have a non-square pixel spacing. The horizontal resolution steps from 704 to 1280, and from 704 to 1920 form clumsy relationships having obtuse factors (20/11 and 30/11). This is further complicated by the non-square pixel spacing of 704 x 480 at either 16:9 or 4:3, and the square pixel spacing or 1920 x 1080 and 1280 x 720. Of greatest confusion is the question of how the 4:3 formats are related to the 16:9 formats. No apparent relationship exists between the formats having these two aspect ratios in Table I. These formats therefore form a jumble, rather than being the basis of a sensible system

The 1280 x 720 proposal originated with the MIT and also the Zenith AT&T proposals from 1989, when these systems were analog. 1280 has been used on computer displays since 1980 in a 1280 x 1024 configuration. However the vertical value 720 is not used by any existing display. Also, 1280 x 720 has the disadvantage that it does not fully fill 1 million pixels. A 1440 x 720 format would be superior, since it would have a 2:1 aspect ratio, and would fill 1 million pixels. However, 1440 and 720 are both resolution values which are inefficient in display systems, due to their obtuse factors. The vertical 720 value bears a 3/2 relationship with 480, which is sensible, but it is otherwise undesirable.

In addition to problems with the resolutions of the formats in Table I, there are also very severe problems with the "Picture Rate". We will now address the "Picture Rate" issues in the right hand columns of Table I.

The frame rates shown in Table I are clearly intended for display on 60 Hz refresh rate displays. The 60 Hz frame rate has its basis in the Victorian Era power engineering of the last century, when Edison and others developed our nation's electric tranmission line systems. Edison chose 60 Hz because of its beneficial properties of electricity delivery over long distance power lines. In Europe, the 50 Hz rate was chosen for this purpose. Neither of these rates were designed with television image display rates in mind. In the 1930's, however, it was difficult to build power regulation circuitry for television receiver displays, and 60 Hz represented a way to display television which had acceptable flicker on the small dimly-illuminated television screens of the day. The technology of image display power regulation was mastered in the 1970's to provide very low cost image display power at any desired display rate. At present, there is no benefit or

requirement for a 60 Hz display rate due to the considerations which led to its adoption as part of the NTSC standard in 1940.

The only desirable rate in Table I is "24P", which is the natural frame rate of motion picture film. The other rates, which are 60I, 60P, 59.94I, 59.94P, 30P, and 29.97P, are clearly intended for use only with 60 and 59.94 Hz displays. Such displays are unsuitable for display of N.I.I. applications, which nearly always include text and graphics. The computer industry abandoned the 60 Hz rate more than half a decade ago. It was widely discovered that 60 Hz results in perceived flicker on display screens that leads to eye strain, headaches, and even nausea. The extremely serious negative medical ergonomic impact of 60 Hz display has been widely recognized, to the point where there are no longer any computer displays larger than 13" that use 60 Hz as a display rate. As screen size expands in the field of view, as would be expected of Advanced Television, and as screen brightness increases, as would also be anticipated, the flicker perception threshold increases to beyond 70 Hz. For this reason, 72 Hz is a much more suitable target display rate for advanced television than is 59.94 or 60 Hz. However, when using a 72 Hz display, moving image material sent at 59.94 or 60 Hz will "judder" and "studder". Such motion artifacts will make 72 Hz display viewing much less desirable than 60 or 59.94 Hz display viewing when the source is 60 Hz. This, in turn, will lead consumers to buy 60 and 59.94 Hz television displays, which are unsuitable for text and graphics applications used by computer-compatible and future envisioned N.I.I. applications. Any fair comparison of a 30 or 60 Hz image rate format from Table I being shown side-by-side on a 60 Hz display next to a 72 Hz display will reveal the extreme quality bias inherent in Table I to the disadvantage of 72 Hz displays. DemoGraFX has prepared a compelling demonstration of the visual appearance of this bias which shows definitively that consumers will not buy computer-compatible displays if the ACATS proposed frame rates in Table I are adopted by the commission. DemoGraFX would like to show this demonstration to the commission, and again extends its offer to the FCC chairman and all the commissioners and staff to view these demonstrations first hand. The commission can also seek independent demonstrations from neutral parties which will show the same extreme bias inherent in the frame rates of Table I against N.I.I. compatible display rates.

Thus, if the commission accepts the frame rate recommendations in Table I, the commission will be effectively precluding any role for Advanced Television in the development of a viable National Information Infrastructure. Since it is widely felt that ATV could be a key ingredient in enabling such a National Information Infrastructure, this lost opportunity would be very significant for our nation.

It is apparent from the Notice that the commission is unaware of this situation. The ACATS proponents are insisting that their proposal is an N.I.I. enabler, not an inhibitor. However, an examination of these proponents shows that many of them would stand to benefit if the convergence of computing and entertainment consumer electronics were thwarted. The commission should be wary of recommendations or compatibility assertions which are made by members of the consumer electronics industry, yet are refuted by members of the computer industry[36]. The computer industry should be seen by the commission as the only credible source

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[36] A clear example of the assertions of computer compatibility being made by the consumer electronics industry, in opposition to the computer industry, can be seen in the EIA submission of reply comments to the commission in the previous notice (the "Fourth Further Notice" Fall 1995) in the same ATV docket as the current Notice. The EIA, which is primarily representing consumer electronics companies, is refuting the submission by Apple computer provided as comments to that previous Notice. Apple clearly points out the computer incompatibility of the ACATS work, and the EIA claims that Apple is wrong, and that the ACATS proposal is computer compatible.

of evaluation concerning the computer-compatibility of any proposed ATV system. As the commission is aware, CICATS is clearly indicating to the commission that the ACATS proposal thwarts computer compatibility and that it thwarts the potential for ATV as an enabler for a National Information Infrastructure. The commission is also apparently unaware that the ACATS proposed system locks out development of such compatible systems, due to the chaos created by the 18 formats in Table I. Market-force scenarios are equivalent inhibitors to convergence with computing, due to the likely flooding of the market by consumer electronics companies with computer-incompatible interlaced digital television sets, and the likely broadcasting of computer-incompatible formats such as 704 x 480 at 60i in Table I. Thus, the commission's only opportunity to establish a computer-compatible ATV system for our nation is to reject ACATS proposal, and establish some mechanism to ensure that a computer-compatible system, as certified by the computer industry, is specified.

To summarize, the formats in Table I, with resolutions of 1920 x 1080, 1280 x 720, 704 x 480, and 640 x 480, with the exception of 640 x 480, are all based upon a series of unsound principles which are built upon one another like a "house of cards". The frame rates of 60, 59.94, 30, and 29.97 are also unsuitable, given their vast incompatibility with computer and text display, which should be considered a requirement for a National Information Infrastructure. The entries in Table I therefore form a set of formats which is unsuitable for adoption by the commission as a United States television standard. New digital format standards for advanced television are a monumental event in the technical history of our nation. These new standards should be based only upon sound principles which truly serve our citizens.

The obvious alternative to the jumble of formats proposed in Table I is the use of a single layered system having flexibility of aspect ratio, and utilizing square pixel spacing. DemoGraFX ATV formats can be found in *Appendix J* for the base layer, and *Appendix K* for the optional enhancement layer. The following Table Ia is a summary of DemoGraFX format recommendation:

Table Ia

Base Layer:		(square pixel spacing)	
Vertical Lines	Horizontal Pixels	Aspect Ratio	Picture Rate
480 min, 512 max	640 min 1024 max	flexible, 1.33 to 2.37	24P or 36P
Resolution Enhancement Layer[37]:		(square pixel spacing)	
Vertical Lines	Horizontal Pixels	Aspect Ratio	Picture Rate
720 min, 1024 max	1280 min 2048 max	matches base layer	= base layer
Temporal Enhancement Layer:			Picture Rate
Available Optionally On the Base or the Base + Enhancement			72P

The "outer template" of these formats is 1024 x 512 for the base layer, and 2048 x 1024 for the enhancement layer. These outer templates have a 2:1 aspect ratio, which is favored by Cinematographers. The optimal wide screen presentation would utilize a 2:1 aspect ratio display. However, displays having 16:9, or 4:3 aspect ratios, or other aspect ratios, could present the same picture data, using either letter-box or pan-and-scan, although letter-box is stongly favored by Cinematographers over pan-and-scan. However, a 2:1 template allows the optimal treatment of the two common wide-screen movie formats of 2.37 : 1 and 1.85 : 1. A 16:9 template, as proposed by ACATS in Table I of the Notice, favors 1.85 : 1 and 4:3, at the great expense of 2.37 : 1. Thus, the proposed template and resolution ranges shown here in Table Ia offer a better treatment of widescreen movies, as well as offering substantial flexibility in aspect ratio to directly transmit entire un-cropped original films, without wasting data on unused letter-box area to fill the undesirable 16:9 template offered by ACATS.

It is directly apparent that this alternative to Table I of the Notice does not contain 59.94 or 60 Hz, and does not contain interlace. How, then, would existing NTSC television shows, or shows which have (prematurely) been mastered in interlaced Japanese HDTV, be sent using this system?

DemoGraFX proposes that such interlaced 59.94 and 60 Hz material be "standards converted" into the formats of Table Ia. The conversion from 60 Hz interlaced to 72 Hz non-interlaced is very similar to existing standards conversion from PAL to NTSC[38].

In high-end home theatres and corporate video presentation rooms, it is now common to see video "line doublers" and "line quadruplers". These devices de-interlace and standards-convert interlaced video into projection formats which are free of interlace. There is general agreement that these devices improve the video signal. This same principle is what DemoGraFX is advocating to the commission regarding interlaced formats which are in current use. The cost of standards converters and line-multipliers is too high to burden every consumer device, as would

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[37] CICATS recommends that only the base-layer be standardized, and that it be left as flexible as possible. DemoGraFX feels that our enhancement layer technique is sufficiently mature that the commission could standardize this layer also, to provide fully standardized HDTV at the inception of ATV, in addition to the base layer. The decoder for this HDTV is approximately equivalent to the decoder for the HDTV formats in Table I.

[38] PAL to NTSC conversion takes 50.0 Hz interlaced and converts it to 59.94 Hz interlaced. This requires similar de-interlacing and 6/5 ratio frame rate conversion as NTSC or Japanese HDTV interlaced formats would require to move to 72 Hz non-interlaced. Thus, existing PAL to NTSC standards converters can serve as an existence proof of the technology required for the standards conversion required to enter the formats in Table Ia.

be required to clean-up the ACATS interlaced formats in Table I of the Notice. However, the cost of these devices is a small portion of the cost of the digital MPEG-2 encoding system required to implement Advanced Television. A DemoGraFX ATV encoding system would be approximately the same cost as the ACATS proposed encoding system. It is the decoding that becomes vastly cheaper, with a greatly improved quality of result, using the DemoGraFX system over the ACATS proposal. Further, the burden of computer compatibility is folded into the encoding via the use of the standards converter.

This DemoGraFX proposal for handling existing NTSC signals should be of interest to broadcasters, since the resulting video signal will be significantly improved for all of their customers, without needing any modification to their existing broadcast production facility.

The main objection to such signal cleanup and de-interlacing has always been that non-interlaced coding was not sufficiently efficient. However, with DemoGraFX ATV system, our improved efficiency now enables this highly desirable scenario[39]. It is highly desirable for broadcasters, since they would achieve a higher quality picture delivered to their customers within a data rate which is similar to the lower-quality interlaced ACATS formats. It is highly desirable to consumers, because they receive a substantially higher quality picture for a lower cost than if they were receiving the interlaced ACATS formats proposed in Table I of the Notice.

3.3. Detailed Comments on The Picture Rates and on Interlace (Paragraph 11 of the Notice)

Although most issues relating to the picture rates and to interlace have been covered in the section 3.2 above, a few further comments are in order.

Interlace was chosen as a method of compressing analog television signals in the 1930's. However, interlace is a very lossy form of analog signal compression. In the field of digital television technology, better techniques for compression are available which do not yield the severe losses and artifacts of interlace.

The interlacing technique damages an image in many ways which cannot be fully repaired. Thus, the use of interlace in video cameras should be made obsolete as non-interlaced capture grows in use for Advanced Television. The commissions action by adopting ACATS would likely significantly delay this transition to non-interlaced cameras, because the ACATS proposal encourages the use of existing NTSC interlaced formats as directly transmitted and displayed, as well as adding the interlaced Japanese format-equivalent of 1920 x 1080 at 60i and 59.94i, with corresponding tape and processing systems in this interlaced format.

However, if the commission accepts DemoGraFX' recommendation to forbid transmission and display of interlace, then broadcasters will be encouraged to purchase non-interlaced equipment to provide the inherently better signal. Television production equipment manufacturers would be similarly encouraged to manufacture such non-interlaced camera and tape system equipment.

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[39] See also the comments submitted 14 June 1996 by William F Schreiber of M.I.T., which includes papers by experts from AT&T Bell Laaboratories, Project RACE (Europe), RAI (Italy), NHK (Japan), and others. Professors Schreiber's comments point out that interlaced formats of a given resolution require the same number of bits to code as non-interlaced formats at the same resolution. The papers which are included with Professors Schreiber's comments substantiate this. DemoGraFX has independently verified this interlace efficiency issue in our own ATV work.

Camera technology without interlace is now fully technically feasible. Tape system technology, processing technology, and switching technology are all now fully technically feasible.

DemoGraFX has demonstrated that transmission technology and coding technology for ATV now can fully support HDTV and SDTV without interlace.

Display technology only benefits from interlace under the certain conditions where normal computer-screen legible text is not required. Further, interlace produces near-unacceptable artifacts on normal scenes. A key impact of interlace is to interfere with text legibility. However, such computer-compatible text is a requirement for a National Information Infrastructure. This is the origin of the slogan worn on buttons by many participants in the 1993 interoperability review. The buttons contained the words: "interlace = illiteracy", indicating the potentially substantial impact on the literacy of our children that could result from accepting the ACATS proposal which contains interlaced ATV.

Further, at the receiver, if some receivers are interlaced and some are not, the interlaced ones will be the "lowest common denominator" of resolution. Thus, any shows or educational material prepared for a broadcaster's population of receivers (including affiliates), will have to be composed for legibility on the interlaced receiver population. The non-interlaced receivers will then therefore show no advantage, since the images sent will be softened vertically to half the vertical resolution that would be possible without needing to filter for display on interlace. Thus, the commission must intervene and prevent not only transmission of interlaced digital television, but also must prevent all new non-NTSC digital television receivers from using interlace. In that way, the entire receiver population would be guaranteed to be non-interlaced, and shows and educational material, and other N.I.I. compatible uses, can be prepared with full vertical resolution.

Thus, the allowance of interlaced displays, even if interlaced transmission is prohibited, automatically forces broadcasters and those who prepare their shows to reduce the vertical resolution to approxmately half on text and graphics material. This leads to a need for substantially enlargement of legible text, resulting in unacceptably low amounts of text available for screen composition.

Although interlaced NTSC receivers will be with us for some time, it is not necessary to constrain digital ATV to be legible on existing NTSC receivers, with the very low available vertical and horizontal resolution. A two-to-one zoom in set-top converter boxes could be used to double the legibility by enlarging text for NTSC display. However, text must be composed in special ways for the result to be acceptable. This is inherently a difficult and complex problem due to the legacy of poor legibility of fine text on NTSC television screens.

DemoGraFX therefore recommends that the commission take this opportunity to improve delivery of legible text by the commission's prohibiting interlaced transmission, and by prohibiting pre-filtering for interlace in the transmission. Such a prohibition would allow ATV become an opportunity to move to new higher resolution formats for the nation, in order to enable an N.I.I.. Thus, in addition to forbidding interlace, the commission should require that all non-interlaced formats be composed to maintain full vertical resolution. In the absence of such a requirement from the commission, the market is likely to have a significant population of at least ten or twenty percent interlaced displays, and possibly much larger, for the 480 and 1080 line ATV format resolutions. Even a small population percentage will be sufficient to motivate broadcasters, advertisers, and those who prepare their shows, to filter the vertical resolution of camera-based images to 2/3, and to filter text to half vertical resolution in order to ensure legibility. Thus, the only way to enable a transition to a fully-non-interlaced N.I.I. is to forbid interlaced receivers as well as to forbid transmission of interlace.

As mentioned above in section 3.2, DemoGraFX sees the rates based upon 30 and 60 Hz, and particularly on 60 Hz interlaced, as being intended solely for display on 60 Hz interlaced displays. For displays which flicker, such as those based upon Cathode Ray Tubes (CRT's), or newer electro-luminescent technologies, 60 Hz has too much flicker for acceptable large screen viewing in normally lighting environments such as the office and daytime home. For displays which do not flicker, such as the Texas Instruments' Micromirror (DMD) or such as Active Matrix Liquid Crystal direct view or projection displays, there is no issue with flicker. However, for these devices, interlace cannot be utilized, forcing the use of a deinterlacer Thus, for every type of computer-compatible display, either 60 Hz or 60 Hz interlace forces extra cost and quality loss.

A typical computer screen runs at over 70 Hz - normally 75 Hz but 72 HZ would also be acceptable. Of the formats proposed, only 24 Hz material originating on film, would provide inexpensive high quality imagery. For 30 or 60 Hz material, motion artifacts will dominate moving portions of any screen. These artifacts manifest themselves as a 15 Hz beat rate, thus resulting in poorer motion than the 24 Hz film material. Therefore, the higher frame rates of 30 Hz and 60 Hz will be completely wasted on computer-compatible displays. In any side-by-side consumer comparison of monitors, the computer-compatible display will actually have an unnecessarily inferior image to that of a 60 Hz entertainment-only television receiver.

In addition to these problems with 30 and 60 Hz, for 60 Hz interlaced formats, the signal must also be de-interlaced and then frame rate converted. The combination of de-interlacing and frame rate conversion results in more artifacts and higher cost than either de-interlacing or frame rate conversion alone. Thus, the 60 Hz interlaced formats heavily bias the viewing public in side-by-side comparisons to buy interlaced 60 Hz entertainment-only televisions rather than computer-compatible 72 or 75 Hz non-interlaced (N.I.I.-enabled) digital ATV receivers.

Thus, DemoGraFX recommends not only that interlaced formats be prohibited, but also that formats based upon 60 Hz and 30 Hz be prohibited.

According to footnote 9 of the Notice, the rates of 24, 30, and 60 Hz can also be operated at a value which is 1000/1001 lower, yielding 23.976, 29.97, and 59.94 Hz. This 1000/1001 factor was introduced into 60.0 Hz NTSC when color was added in 1952 by the NTSC-2 committee. The reasons for this adjustment factor related to saving vacuum tubes in flip-flops at the transmitter, and offsetting the harmonics of the sound carrier from the picture carrier and color subcarrier. None of these issues that motivated this 1000/1001 offset is relevant in the 1990's. Thus, the recommendation of allowing 23.976, 29.97, and 59.94 Hz is based upon obsolete issues. It is presumably being recommended based upon backward compatibility of broadcasting studio clocks with existing facilities. However, conversions from NTSC systems having the 1000/1001 offset to remove this offset can be handled prior to the encoder, in the same way that PAL to and from NTSC standards converters remove this factor. DemoGraFX recommends this method of standards conversion prior to the encoder as the method of eliminating these issues. Thus, DemoGraFX proposes only allowing 24.0, 36.0, and 72.0 Hz. DemoGraFX recommends that the commission disallow the use of the 1000/1001 offset in any new digital ATV systems for the United States.

3.4. Detailed Comments on The 18 Different Formats (Paragraph 12 of the Notice)

This paragraph states:

"Accounting for the different aspect ratios and picture rates identified in Table I, there are 18 video scanning formats allowed by the ATSC DTV Standard. An attractive feature of the ATSC DTV Standard is that the appropriate format would be chosen by the broadcaster..."

As mentioned above, although this may be desirable from the perspective of the Broadcasters who participated in ACATS, it is highly undesirable from the prespective of receivers which must be able to accept 18 widely different formats. These formats span a range of a more than a factor of six in resolution, a factor of two and a half in frame rate, and a range of more than eight in image data bandwidth (as measured in pixels/second).

Each of these formats is intended by the ACATS proposal to be used one-at-a-time by any given broadcaster, although the format can be switched constantly by that broadcaster. Thus, a digital ATV set on the receiving end of this wide array of formats would be subjected to ever-changing conversion requirements, even when tuned to only a single broadcaster as the signal source. Switching between broadcast signals would also lead to other alternate formats, requiring further changes in the conversion requirements. While all of this is both conceptually and practically problematic, the greatest difficulty arises from the nature of the HDTV formats.

The HDTV formats of 1920 x 1080 at 60i, or 30p, and 1280 x 720 at 60p each require processing exceeding 55 MPixels/second. Further, the 1920 x 1080 format requires 2MPixels of decoding memory, even if the display is at a lower resolution[40]. The cost of these decoding requirements is substantial[41]. This cost would burden every receiving device, even if its display operated at a much lower resolution and/or frame rate.

If this weren't sufficiently problematic, the situation becomes substantially more costly and artifact-prone when considering the conversions needed for the 30 and 60 Hz interlaced and non-interlaced formats to a computer-compatible display running at 72 Hz or 75 Hz. This additional conversion at each such receiver may more than double the cost of the decoder over the already high cost of the entertainment-only receiver[42].

This notion of allowing transmission of 18 widely disparate formats is the most problematic idea in the entire ACATS proposed system. It is made further difficult by the formats themselves, which are based upon 60 Hz and which contain interlaced formats.

It would be difficult to imagine a set of technology barriers to prevent computer-compatible receivers which is any more formidable than those erected by ACATS in their proposal. By accepting ACATS proposal, the commission would be establishing these barriers into rules of law, thereby placing formidable barriers against the use of ATV in the development of an N.I.I. for this nation.

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[40] Hitachi has made a proposal that would attempt to decode the HDTV formats with reduced memory and processing directly into a lower resolution image by discarding coefficients. However, DemoGraFX feels this proposal is not sound, due to forward prediction errors which would result in serious picture artifacts. Forward prediction is the main mechanism by which MPEG-2 achieves high quality results at the high compression ratios that it can achieve. Processing MPEG-2 by decoding without accurate forward prediction can result in the loss of much of the quality and compression efficiency achieved by MPEG-2.

[41] CICATS has studied the cost difference between a DemoGraFX-like base layer decoder vs decoding the ACATS formats. CICATS is submitting these cost estimates in a separate comments submission in response to this Notice.

[42] This estimate is based upon the expectation that the amount of logic and memory associated with standards conversion in the receiver will be similar to the amount of memory and logic associated with the MPEG-2 decoding.

Even if these computer-compatibility barriers are not considered, the ACATS proposed system would cost consumers substantially more than a layered ATV system utilizing a low-cost base layer decoder, such as the one being proposed by DemoGraFX.

Paragraph 12 goes on to say:

"Similarly, the DTV broadcaster would be able to pass through program material it receives from an outside source in any of these formats."

Although it is certainly feasible for an affiliate broadcaster to pass through the analog modulated digital signal unmodified, it is often desirable for such broadcasters to modify the signal in various forms of localization. Various local messages such as hurricane or tornado warnings are often locally superimposed upon national feed programs[43]. The ends of shows are sometimes reduced in size, allowing local newscasters to introduce upcoming news stories during the credits. There are numerous other examples in common practice where local information is combined with the incoming national feed. In such cases, conversions will be required if the local origination format does not match the incoming national feed format. The number of combinations of such conversions and formats is very large. The 18 Formats proposed by ACATS can be combined in 171 ways! That is to say, that there are 171 possible pairs of combinations of formats of an incoming ACATS format and a local broadcaster-originated ACATS format. Although this may not require 171 different converters, it will require the ability to convert the 18 incoming formats into each format that is locally originated.

These conversion problems seem to DemoGraFX to be an excessive burden on affiliate broadcasters.

Paragraph 12 goes on to say:

"The identified scanning formats are those used within the DTV system and most of them relate to existing television production standards. However, material in any other format can be converted into one of the allowed scanning formats. Thus, development of additional video production formats can take place recognizing the scanning formats of the ATSC DTV Standard, but not constrained by them. Similarly, when considering the receiver, most display devices are expected to have a "native" scanning format (which may be one of these system scanning formats) to which the received video signal would be converted."

The two formats in Table I of the Notice which relate to existing television production standards are the interlaced formats of 1920 x 1080 at 60i in the 16:9 aspect ratio and 704 x 480 at 59.94i in the 4:3 aspect ratio. A prompt adoption and implementation of the ACATS proposal will result in these two formats becoming the likely defacto ATV standards for the United States to the initial preclusion and subsequent hindrance of all of the non-interlaced formats. If the commission wishes to see the United States pursue a forward looking non-interlaced ATV system, the commission will need to provide both time and incentives to allow non-interlaced formats to enter and capture the market. The most efficient method of achieving this is to disallow the interlaced formats for both transmission and display. This would allow the existing interlaced equipment to be used as a source for ATV, through the use of a standards converter at the input to the ATV encoder. However, it would encourage the development and use of non-interlaced production equipment, since the signal quality would be most optimal and the system elements would be most efficient if interlace is removed from the production system. Without

[43] Although such messages could be placed in overlay planes, there are no such overlay planes defined within the ACATS proposal.

such encouragement, the possibility becomes likely that interlaced formats would form the majority of broadcast signals, and digital ATV interlaced receivers would be sold into the majority of homes.

The Notice goes on to say that "material in any other format can be converted into one of the allowed scanning formats". This concept is similar to DemoGraFX proposal that the interlaced formats be scan converted into computer-compatible non-interlaced 72 Hz formats.

However, the notion that computer-compatible formats should be converted into the computer-incompatible 60 Hz and interlaced formats which are "allowed scanning formats" within the ACATS proposal is unacceptable. For example, ACATS is proposing that a 72 Hz non-interlaced format, would need to be converted into a 60 Hz interlace or non-interlaced format for transmission. It would then have to be converted back into 72 Hz. It would further need to be de-interlaced if it had been interlaced for transmission. Both of these operations will lose signal quality and add significant cost to the receiver.

The next sentence in the Notice goes on to say "Thus, development of additional video production formats can take place recognizing the scanning formats of the ATSC DTV Standard, but not constrained by them." This statement does not appear to be correct. The formats in Table I are constrained to 24, 30, and 60 Hz. These formats are further constrained to the resolutions of 1920 x 1080, 1280 x 720, 704 x 480, and 640 x 480. Formats are further constrained to the aspect ratios of 4:3 or 16:9. Formats are constrained to not used layering. The DemoGraFX format of 2048 x 1024 at 72 Hz, non-interlaced, with two layers of resolution and two layers of temporal rate, cannot be accommodated within any format or format combination in Table I. Thus, the notion that new formats can be developed and accommodated within the ACATS proposed formats is demonstrably incorrect by any number of counter examples, including the formats of the DemoGraFX system.

The ACATS formats prevent new formats and innovation. It is not just that new formats, such as the one that we propose, are "constrained" by the ACATS proposal. They are absolutely and inexorably prevented. Deployment of a non-layered format set, as proposed by ACATS in Table I, absolutely precludes useful deployment of a layered system. Layered ATV is precluded by ACATS. There is no way to extend, modify, or work within the formats shown in Table I to build a layered ATV system.

The image area of movies having different aspect ratios than 16:9 or 4:3 is also "constrained" by the ACATS proposal. For example, the common widescreen movie format, with an aspect ratio of 2.37 : 1, occupies only 75% of the height of the 16:9 ACATS proposed HDTV formats, only 62% of the 704 x 480 ACATS proposed 16:9 SDTV format, and only 56% of the 4:3 ACATS proposed formats[44]. Such loss in height, due to letterboxing, is a very serious constraint on the image delivery performance of the ACATS proposed system.

In addition to these problems with the 16:9 aspect ratio, the very commonly used 4:3 aspect ratio, such as that used by NTSC, is not available at high resolutions in the ACATS proposal. Computer screens are typically high resolution 4:3 images. Such displays cannot utilize the ACATS 16:9 formats to fill the screen without either cropping the sides or letterboxing the height

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[44] For comparison, the 2:1 aspect ratio image template recommended by the ASC and by DemoGraFX, with square pixel spacing, presents a 2.37 : 1 movie in 84% of the height. The other common movie format, 1.85 : 1, fills 92.5% of the width of the image on a 2:1 aspect ratio image template. The 2:1 aspect ratio therefore forms a far better unifying aspect ratio for widescreen movies.

within the 4:3 screen shape. This is yet another "constraint" placed on image formats attempting to use the ACATS proposed formats.

The next sentence of the Notice goes on to say "Similarly, when considering the receiver, most display devices are expected to have a "native" scanning format (which may be one of these system scanning formats) to which the received video signal would be converted."

This sentence proposes the fundamental notion of the 18-format ACATS proposal. This notion is that every receiver converts all 18 formats into a "native" format, which ACATS anticipates may be one of the formats from Table I.

Since all of the formats in Table I are based upon 60 Hz favored and intended display, and are highly biased against 72 Hz non-interlaced display, the conversion required for such 72 Hz display has been made expensive for the 30 and 60 Hz formats. This is especially true for the 60 Hz interlaced formats. 60 Hz interlaced and non-interlaced formats will also result in a loss of quality, the amount of such loss dependent upon the cost, and therefore quality, of the conversion system in the receiver. DemoGraFX feels that conversion from the interlaced HDTV format in Table I, at 1920 x 1080 at 60 interlaced, to 72 Hz non-interlaced, will be very expensive.

This set of problems and issues caused by the 18 formats are greatly simplified through the use of a layered system which does not contain interlaced formats, such as the one being proposed by DemoGraFX.

DemoGraFX recommends that conversions occur prior to encoding at the broadcaster end of the system. Such conversions can then yield computer-compatible high-quality image results.

3.5. Detailed Comments on Video Coding (Paragraph 13 of the Notice)

DemoGraFX ATV system utilizes the same basic MPEG-2 technical ingredients as are described in paragraph 13 of the Notice. However, there are several crucial differences. The DemoGraFX ATV system provides layered compression, which is not efficiently provided by MPEG-2 spatial scalability. Layered compression is highly desirable for reducing the cost of decoders in receivers which operate at low and intermediate resolutions. It also provides very high quality for such decoders.

Also of great significance is that the DemoGraFX Layered ATV system outperforms normal MPEG-2 by a substantial margin. DemoGraFX is achieving 2.4 times more compression ratio efficiency of video coding than the ACATS Grand Alliance HDTV proposal which is the subject of this Notice.

The other major difference is that DemoGraFX ATV system is layered in frame rate as well as in resolution. The frame rate layering allows B frames[45] to be utilized for temporal enhancement in receivers which support faster motion rendition, while allowing lower-cost decoders which need not interpret B frames to receive motion which is less smooth, but still high quality.

DemoGraFX does not use the "main profile syntax" of the MPEG-2 video standard, since this profile does not support layering, and since it is limited to 60 Hz maximum frame rate. No

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[45] B-Frames add significant cost to decoders, and should therefore only be utilized in enhanced premium receivers. The base layer ATV signal should not be burdened with manditory B frames, as is being proposed by ACATS.

profiles within the MPEG-2 video standard are relevant to the DemoGraFX ATV standard, although the DemoGraFX ATV system utilizes the MPEG-2 encoding and decoding standard as the basic compression/decompression engine.

The complexity and cost of encoding DemoGraFX layered ATV format is similar to the cost of encoding the ACATS HDTV formats. The cost of encoding the DemoGraFX base resolution and temporal layer (24 and 36Hz), is similar to the cost of encoding the ACATS SDTV formats which operate at 24, 30, and 60i. The cost of encoding the temporally enhanced (72Hz) base layer is similar to the cost of decoding the 60p ACATS SDTV formats. Thus, DemoGraFX Layered ATV system is similar in cost of encoding in all aspects.

DemoGraFX ATV system is much higher quality in decoding than all ACATS proposed formats, both HDTV and SDTV. DemoGraFX ATV system is much lower cost and higher quality when decoding from the base layer onto SDTV-class receivers, than the ACATS proposed HDTV formats decoded onto the same class of SDTV receiver.

Thus, the main advantages of the DemoGraFX ATV system video coding are the elimination of interlace, to provide computer compatibility, the provision of a 72 Hz display rate with optimal quality and lowest decoding cost, and high quality low cost decoding of the base layer to provide affordable ATV. This affordable ATV is substantially higher quality than NTSC, and is somewhat higher quality than any of the ACATS proposed SDTV formats, including the 60p formats.

The DemoGraFX system also provides layered 24frame-per-second movies in the 2048 x 1024 template, within 8mbits/second. This 8mbits/second is comprised of 4mbits/second for the widescreen-movie base layer, and 4mbits/second for the enhancement layer which results in full HDTV. Thus, DemoGraFX system allows two full HDTV movies, at the highest resolution, to be contained within the 19.3 mbits/second provided by the ACATS-proposed modulation system. Further, on cable, four such HDTV movies can be carried within one 6-MHz channel, based upon the doubling of capacity for cable (described in paragraph 17 of the Notice)[46].

DemoGraFX realizes that all of these claims may appear bold. Thus DemoGraFX recommends that the commission seek independent unbiased evaluation to verify these assertions.

3.6. Comments on Audio Coding (Paragraph 14 of the Notice)

DemoGraFX accepts the work of ACATS and their proposal in audio. The commission is probably aware of the controversy surrounding Dolby AC-3 vs Philips' Musicam, which is the basis of the MPEG-2 standard. It would be desirable if only a single format of audio decoding were to be needed in receivers. At present, each of these two systems appears to be competing for the market.

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[46] Using DemoGraFX layered MPEG-2 system, formats in the 2:1 aspect ratio near 1280 x 720 at 24p, as proposed in Table I, are possible with even lower bit rates. The format 1440 x 720, with a base layer of 720 x 360, can be carried with full fidelity within 5.5mbits/second, 2.75mbits/second for the base layer, and 2.75mbits/second for the enhancement layer. The format 1280 x 640 with a base layer of 640 x 320 utilizes a slightly lower bit rate. Thus, three complete layered HDTV movies in these formats could be contained within the 19.3mbits/second of terrestrial broadcast, and six such movies on one channel on cable systems. However, such numbers are somewhat incompatible with DemoGraFX's proposed 2048 x 1024 HDTV layer, and 1024 x 512 ATV base layer. Thus, DemoGraFX is not recommending either 1440 x 720 nor 1280 x 640. (Note that DemoGraFX proposed 2048 x 1024 HDTV layer has almost the same number of pixels as 1920 x 1080)

If the commission can find a way to cause only a single format of audio decoder to be needed in consumer receivers, that would reduce cost over the alternate scenario in which two such decoders are needed.

The use of 384 kilobits per second (kbps) for full surround sound, or less for stereo or mono, allows the remaining bits to be used for video coding and ancillary data uses. However, DemoGraFX does not know if this is a sufficient data rate for high quality audio. A layered audio system design could utilize a base layer and enhancement layers (although strictly in signal-to-noise-ratio, SNR) to yield similar benefits to the layered video system. The commission may wish to further examine the quality and performance of the audio recommendations being made by ACATS.

3.7. Detailed Comments on Transport (Paragraph 15 of the Notice)

This paragraph states:

"The ATSC DTV Standard has been optimized for terrestrial digital television delivery, where channel bandwidth is limited and transmission errors and data loss are likely."

The paragraph goes on to say:

"Data describing multiple television programs, or unrelated data for other purposes, are also combined in the transport layer".

When these statements are considered, it can be seen that the ACATS transport packet system is not designed for reliable data delivery, and yet it is claiming to support unrelated data for other purposes. DemoGraFX feels that the potential uses of the system are greatly limited by the unreliable data delivery aspects of the ACATS transport proposal.

While the MPEG-2 systems transport packet system may have error performance suitable for carrying audio and video, this high error rate is not suitable for most anticipated N.I.I. uses. Web browsing on the internet, for example, would not be feasible with high anticipated data loss. New web tools, such as the Java programming system from Sun, and ShockWave from Macromedia require error-free data in order to operate at all.

One can imagine many applications which cannot tolerate high data loss rates. Examples include educational material, health care, banking, shopping, and many others. It is readily apparent that banking utilizing high-error-rate data would be useless. Many commercial applications involving reliable data receipt would be precluded with the ACATS level of data errors.

ACATS made a major oversight when it did not develop technology to allow reliable data transmission within the main broadcast coverage area.

The additional design technology required to provide low-error-rate and low-data-loss would be based upon an additional layer of error-interleave. With a suitable interleave time span, and a suitable error-correction code, a reliable data stream could be decoded. The interleave time span would need to be thoroughly tested, representing another serious oversight in the work of ACATS. However, DemoGraFX estimates that an interleave time span of 1/2 second, corresponding to the decoding delay of an ACATS or DemoGraFX MPEG-2 decoder, would likely be able to provide data which is sufficiently error free over the main broadcast coverage area. Separate testing would also be needed for cable systems.

ACATS has proposed that error correction be performed "under" the "private data" portion of MPEG-2 transport and program streams. However, such a proposal would yield highly inefficient data carriage, since the headers which would identify this data would have high error rates. The more correct approach to providing error-free data within the coverage area is to design a robust code at the current layer of MPEG-2 transport, probably using out-of-band codes in the existing ACATS Reed Solomon decoder, to provide two levels of error correction. This would allow the audio and video to have the full data rate of the channel, yielding the 19.3 mbits/second maximum full-channel rate. It would further allow reliable data delivery at about 85% of this rate, or approximately 16.5mbits/second, as the full-channel maximum rate for high reliability data. Any mixture of the two data reliability levels should be feasible with a correctly designed system.

By attempting to pursue the ACATS recommendation that extra error correction be added to the "private data" area in MPEG-2 transport, DemoGraFX feels that the likely result would be a loss of approximately a factor of two. Thus, only about 8mbits/second of reliable data would be available from the full 6MHz channel, vs. the 16.5mbits/second which is possible with a correctly architected third layer of error correction[47].

Thus, for data uses, the spectrum efficiency penalty from accepting the ACATS proposed transport is likely to be a factor of two loss in efficiency of spectrum utilization.

DemoGraFX therefore recommends that the commission not accept the ACATS transport packet and error correction proposal. The commission may wish to consider chartering an expert group to redesign the transport system to be efficient for data uses

3.8. Detailed Comments on the Receiver (Paragraph 18 of the Notice)

To quote paragraph 18, "The ATSC DTV Standard does not specify requirements for a compliant receiver. In essence, the DTV receiver designs are to be based on the specifications of the signal contained in the other portions of the Standard."

DemoGraFX feels that ACATS has this proposal conceptually backward. DemoGraFX feels that the ATV standard should be defined by a "reference decoder"[48]. By doing this, any legal ATV signal which can be decoded by the reference decoder would be allowed. By defining the reference decoder, the rest of the encoding and transmission system would be sufficiently specified.

DemoGraFX recommends that the commission consider the approach of standardizing ATV reference decoders for a base layer level (similar to the ACATS proposed SDTV formats) and for the HDTV level (similar to the ACATS proposed HDTV formats). A suitable base layer is shown with sufficient specification in *Appendix J.* A suitable enhancement layer set (temporal and resolution) specification is shown in *Appendix K.* With a layered system, these two reference decoder designs would be sufficient to specify the format portion ATV for the United States, and would replace the 18-format proposal of ACATS. The complete ATV specification would then add the specification for the demodulation, error correction decoder, packet structure decoder,

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[47] Approximately double these data rates should be available on cable.

[48] The concept of defining the ATV system by a reference decoder was proposed by Ben Yung of Apple computer, and subsequently was endorsed by CICATS and DemoGraFX.

overlay plane syntax decoding, and for audio decoding. If the error correction packet structure were to be re-worked to provide error-free data delivery, the system would then be complete.

DemoGraFX also recommends that the commission set a receiver specification which disallows the use of interlace in receivers when receiving digital ATV signals. For backward compatibility, NTSC receivers would use a converter box. However, if the commission also were to adopt DemoGraFX' recommendations that interlace not be allowed in transmission formats, and that images not be filtered below full vertical resolution of these non-interlaced formats, then the NTSC display would not provide legible text. For this reason, the commission may wish to consider a reference decoder box design also, including a zoom mode for making digital ATV format text legible on old interlaced television displays.

For new digital ATV HDTV and base-level receivers, the reference decoder would neither receive, decode, nor display interlace.

DemoGraFX also recommends that the reference decoder contain the definition for overlay planes. Some number of overlay planes would allow the ability to send digital data for display on receivers in such a way that the resulting image would be able to persist. MPEG-2 images are inherently ephemeral, so as to be completely erased with each new frame. Overlay planes, however, can allow for locally-inserted messages, such as tornado warnings, to be sent to the screen, and optionally flashed, using only simple packet insertion at the local broadcaster.

For educational uses, locally generated text, icons, and graphics are the basis of interactivitity. Specification of overlay planes in the reference ATV decoder would be very beneficial to many such N.I.I. applications.

One or more reference language syntaxes are also needed, which allow a common way to present fonts of text and graphics onto the overlay planes within the reference decoder. The microprocessor which is required for such text and graphic rendering onto the overlay planes is also best specified as part of the reference decoder. Such specification would ensure interoperability. Note that error-free data delivery is a requirement for the interpretation of text and graphics commands for use with the overlay planes.

DemoGraFX recommends that receiver overscan be disallowed in new digital ATV receivers. Thus, we recommend that receiver overscan be eliminated from the proposed reference decoder. In order to recognize the need for this, it is only necessary to consider computer screens, where key control menu bars are placed at the very edge of the screen. Such computers cannot be operated unless the entire image is visible. Interactive N.I.I. uses require that receiver overscan be eliminated from future ATV receivers.

3.9. Detailed Comments on Flexibility (Paragraph 19 of the Notice)

As described in detail above, in section 3.7 discussing paragraph 15 on transport, the ACATS transport system does not provide error-free data delivery.

Paragraph 19 of the notice claims that the ACATS system "accommodates a broad range of uses". This is an overstatement, since the range of data applications which can tolerate high error loss is very limited. The paragraph goes on to state that the "packetized transport structure is a critical component of achieving this broad range of flexibility". Since the packet headers and data are not error-free, the packet structure is only useful for applications which can tolerate data loss. This excludes internet uses, electronic commerce, electronic mail, education, health care, and most other N.I.I. applications. Other than audio and video, which can tolerate the loss rate of ACATS, there are very few, if any, other applications which can function properly at these error rates. Having a packet structure only makes the situation worse, since the packet headers are

unprotected, thus leading to not only errors, but also may steer messages to the wrong applications. Thus, applications would recieve not only errored data and missing data, but also unwanted data.

The packet identifiers (PID's) are used by the ACATS-proposed MPEG-2 transport system as the header which determines the meaning of the data in each packet. However, the PID field is only 13 bits, allowing only 8192 maximum types of packet. This is too few types to be useful for may applications such as internet browsing and email. Thus, a secondary "adaptation header" and "private data" header system must be utilized to further identify packets. "Private data" is reserved for private uses, and is therefore not a standardized or publicly available format specifier. The resulting system that would be required for "accommodating a broad range of uses" has a compound packet structure which has not been defined or standardized by either MPEG-2 nor ACATS.

Thus, as proposed by ACATS, the ATSC DTV standard is not presently flexible, nor is it presently capable of a broad range of uses.

DemoGraFX recommends that a different, and more universal, header system be developed concurrently with the development of an error-free transport system. Both would be required to enable the broad range of uses being claimed, but not provided, by ACATS.

3.10. Detailed Comments on Extensibility (Paragraph 20 of the Notice)

In this paragraph, the limited PID field is claimed to be a mechanism to provide extensibility to new features to augment DTV programs. The example of migration to 1080-line progressive scan formats is given. However, this is not a plausible scenario. Since the existing ACATS proposal uses all of the available 19.3 mbits/second for the 1080-line interlaced formats, there is no data room available to make a progressive scan format. The inefficiencies of interlace, combined with the weaknesses in the ACATS proposed use of MPEG-2 allow no room for such an augmentation.

Although the PID is a very weak header, it is a basic form of identifier. However, the lack of checksum or other robustness check on the PID makes it virtually useless within the high error rates delivered by the ACATS proposed MPEG-2 transport and error correction system. Thus, extensibility to most new applications is precluded due to the insufficiency and error-prone nature of the PID identifier. The "sub-identifier" defined in the MPEG-2 transport system is known as "private data". However, this mechanism is further complicated by lack of error protection or checking on the PID, since the
"private data" identifier is a further level below the PID, and requires the PID to be valid, which cannot be ensured. In addition, "private data" is completely undefined, and therefore forms a vague header mechanism, currently intended only for proprietary and private extensions. Thus, non-proprietary national or regional extensions which would represent new services for ATV are not defined or guided in any way by this mechanism.

The concept of using unique header identifiers to allow new services to be deployed, but which are ignored by older receivers in the field, is a good one. However, header capabilities alone do not yield such complex upgrades as the migration from interlaced 1080 to progressive 1080. In fact, no viable strategy was every formulated by ACATS for how such an upgrade might be achieved, either technically, or in the market with the installed receiver base. The fact is that there is no migration path, whether there is a header or not. A header does not make a migration path, it only identifies data types. No data types can build a migration path. Deployment of interlace will be permanent, and headers will not provide any "extensibility" mechanism to undo the permanence.

The 18 ACATS formats further complicate matters, since the concept of "extending" these formats has little meaning. The formats are already all over the map in quality, frame rate, and resolution. The ACATS concept is to "switch" formats to higher resolutions to gain higher quality, not "extend" formats to improve quality.

The DemoGraFX layered MPEG-2 system provides a much more appropriate mechanism for extensibility, since layering is an optimal way to provide image quality upgrades and enhancements. Layering provides true extensibility in image quality. Temporal layering provides frame rate quality extensibility, and resolution layering provides extensibility in picture clarity.

New features would be enabled if a more robust and general purpose header system were to replace the ACATS proposed PID system.

3.11. Detailed Comments on Adopting the ATSC DTV Standard (Paragraph 21 of the Notice)

To quote from this paragraph, "We believe that the proposals discussed herein would enable consumers, licensees and equipment manufactureres to realize the benefits of standards without unduly restricting innovation and competition."

While we agree that standards are needed in digital television for the United States, we disagree that the ACATS proposal which the subject of this Notice would provide these benefits. From the perspective of the consumers, we have added cost, and the lost functionality from the 60 Hz interlaced barrier to computer compatibility. Thus, consumers will buy new "digital" televisions, only to find that text is illegible, and that there are none of the expected benefits to families in the areas such as healthcare and education. One can imagine the reaction of consumers when they are told that they have to discard their "new" digital television sets to "migrate" to computer compatible systems.

For licensees, the need to pass through so many formats, and to process them to apply local messages (such as tornado warning messages), is not a benefit of standardization. Standardization in this context would be best if there were a single "base-layer" format, which is always present, which can be processed at low cost by the local licensee to provide needed local services. Further, the DemoGraFX proposed concept that existing NTSC interlaced equipment be de-interlaced and converted to a computer-compatible 72 Hz frame rate would allow current broadcasters to provide a premium picture from their existing equipment, much as line-doublers and quadruplers provide a premium picture.

Equipment manufacturers in the television consumer electronics industry may indeed benefit from the artificial barriers to computer compatibility which are nailed in place by the ACATS proposal with its 60 Hz interlaced formats. However, these manufacturers do not represent any incremental benefit in services to the American public, since such incompatible services will be the same news, sports, and entertainment that we already receive using NTSC. The potential for Advanced Television lies in the new services which can be enabled via computer compatibility. Computer integration with future digital television also requires the benefits of standards, although such standards must foster such integration, not prevent it as does the ACATS proposal.

As for "unduly restricting innovation and competition", it is clear that competition by computer manufacturers is heavily blocked by the ACATS proposal. Innovation, such as the DemoGraFX layered MPEG-2 system, is also totally blocked by the acceptance of a non-layered system as proposed by ACATS. The lack of data robustness, and the weak header capability also block innovation in the direction of new computer-like and interactive services.